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PowerFibers: Thin-Film Batteries on Fiber Substrates

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Under a DARPA contract ITN has developed solid-state thin-film rechargeable batteries on fiber substrates for energy and power storage in novel stand-alone thin-film battery applications, power composites, and electrotextiles. The basic solid-state thin-film rechargeable battery technology was first invented at Oak Ridge National Laboratory, TN, USA, in the '90s and since 2000 has been taken to next level by ITN with the invention of PowerFibers, which were first demonstrated in early 2001.

The basic concept of PowerFibers is to marry power/energy properties with mechanical properties while making the thin-film batteries become a part of and take over some functions of the load-bearing mechanical structure. This novel design reduces the mass and volume fraction of the parasitic, non-power supplying, strictly mechanical parts in applications where those dimensions are critical.

In addition to this basic concept, PowerFibers provide a unique form factor, defined by a large length-to-diameter ratio, that permits small bending radii and substantial flexing. Such mechanical properties are prerequisites for potentially using PowerFibers in novel thin-film battery applications.

An advantage of PowerFibers over flat flexible thin-film batteries fabricated on foil substrate is the inherently larger surface area of PowerFibers which in turn is proportional to the power and energy of a given type of thin-film battery. Thus, for example, a thin-film battery fabricated on a 50 micrometer thick foil substrate of 1cm x 1cm area has a maximum available battery area of 2 square centimeters (double-sided fabrication) compared to 6.28 square centimeters of two layers of 25 micrometer thick PowerFibers of 1cm length.

At ITN PowerFibers have been fabricated as a) single, power supplying fibers as alternatives for flat, thin-film batteries and b) power composites containing tens to hundreds of PowerFibers. The PowerFibers in the power composites were cycled electrochemically under ambient conditions for more than 2000 times while losing less than 0.025% capacity per cycle.

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